



Lunar Laser Communication  
Demonstration

LLCD

# OCTL Overview

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Mission Operations

Lunar Lasercom OCTL Terminal (LLOT)

Jet Propulsion Laboratory

California Institute of Technology

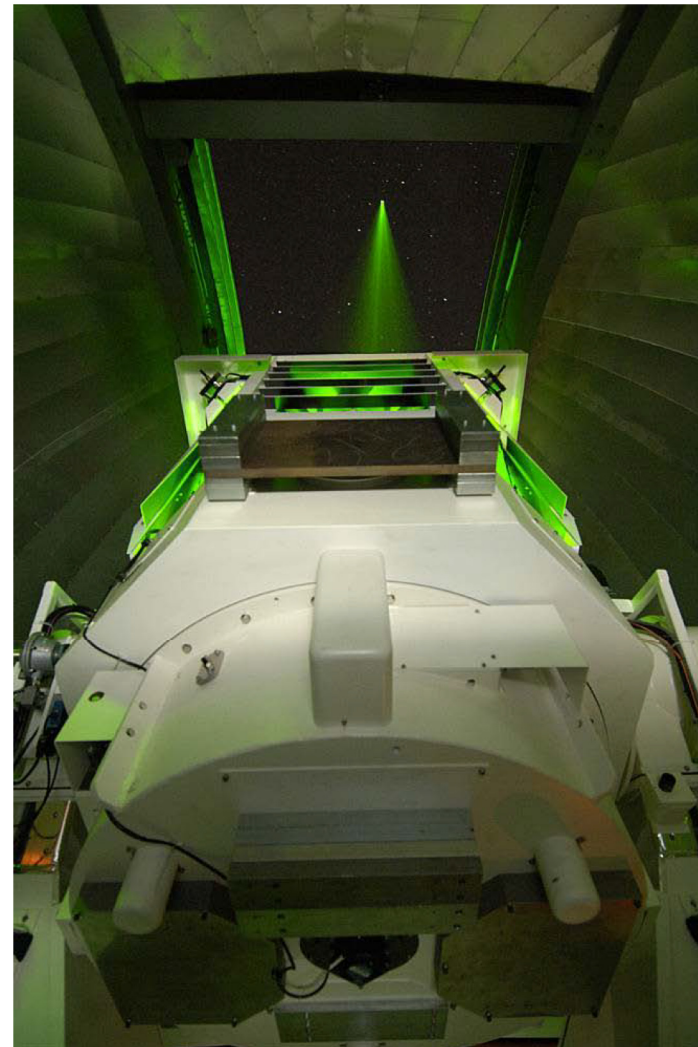
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# Overview



- **Optical Communications Telescope Laboratory (OCTL) description**
- **Safety System**
- **Blind Pointing**
- **Satellite Retro Reflector Experiments**
- **OICETS Optical Communications Experiment**
- **Real Time Control Upgrade**
- **LLCD Configuration**

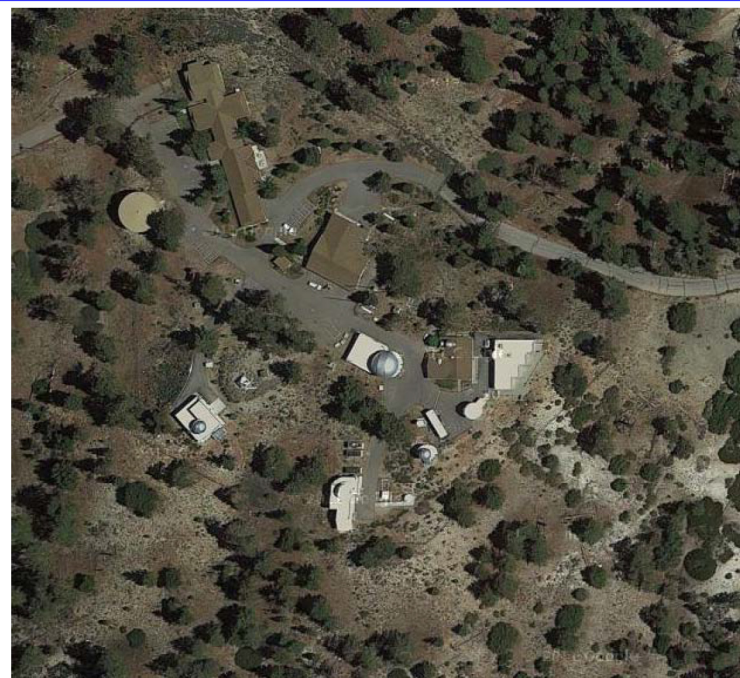




# OCTL



- **Location:**
  - San Gabriel Mountains Wrightwood ,California
    - 34°22.9' North Latitude, 117° 40.9' West Longitude
    - 2.2km (7400 ft) altitude MSL
  - Convenient access from JPL
    - lodging accommodations
- **Optical configuration:**
  - 1-m Az/El telescope
  - F/75.8 seven-mirror coude optical path
  - 4 separate transmission/receive ports
  - <17  $\mu$ rad blind pointing and tracking error
  - Track rates: 20 deg/sec azimuth, 10 deg/sec elevation
  - Full daytime operation
    - Points and tracks to within 10 degrees of sun
    - Filter supports 3-degree sun angle operation
- **20 cm Acquisition telescope**
  - F/7.5 Newtonian
  - Instrumentation support and cabling
- **Supports other testing**
  - Small gimbals for other experiments
  - 1-4 km range testing to opposing mountainside



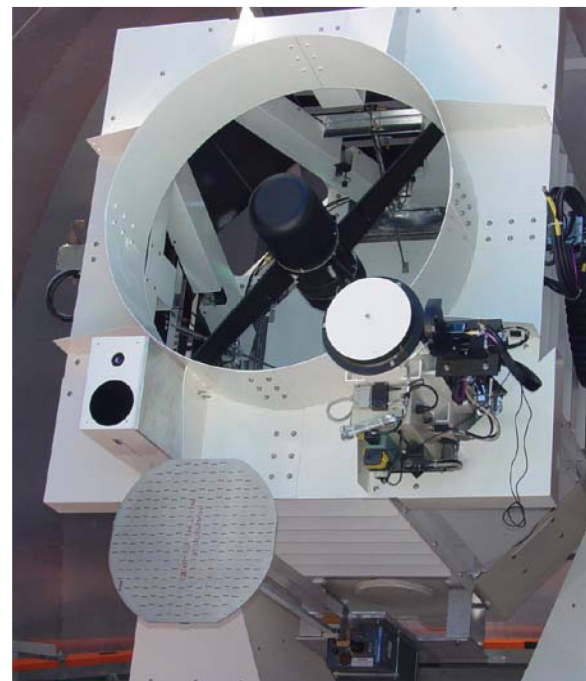
3-LLOT



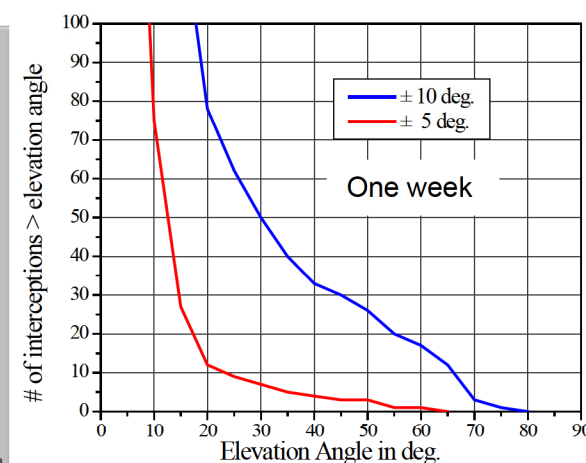
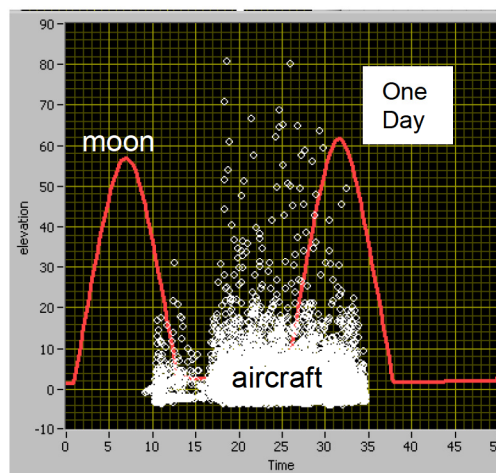
# Laser Safety System



- **3 tier laser safety**
  - **Tier 1: Sea Level to 11,000 ft**
    - LWIR camera
      - Wide and Narrow field
      - Identify target in wide field
      - Shutter laser when enters narrow field
    - Radar
      - Shutter target when target enters field
  - **Tier 2: Sea Level to 60,000 ft**
    - FAA airspace
    - No precaution if laser is eyesafe at plane location AND laser not visible by human eye
    - Spotters required otherwise
  - **Tier 3: 60,000 ft to Space**
    - Pointing information sent to USAF Space Command
    - Predictive Avoidance Files are returned with times when laser must be shuttered



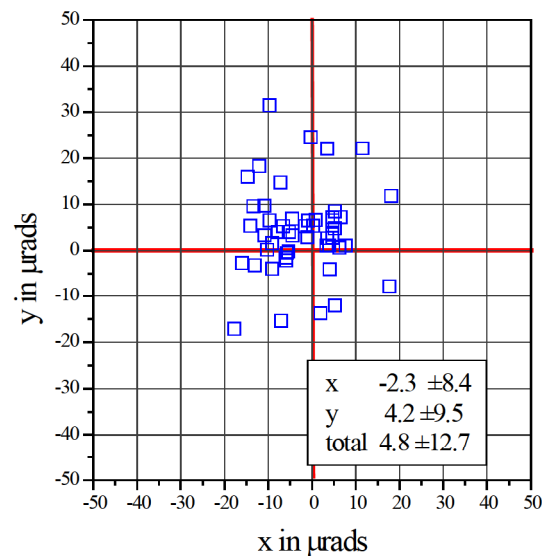
- **Aircraft Interruptions**
  - FAA data collected for one week
  - Also collect data with safety system
  - Most aircraft below 20° elevation



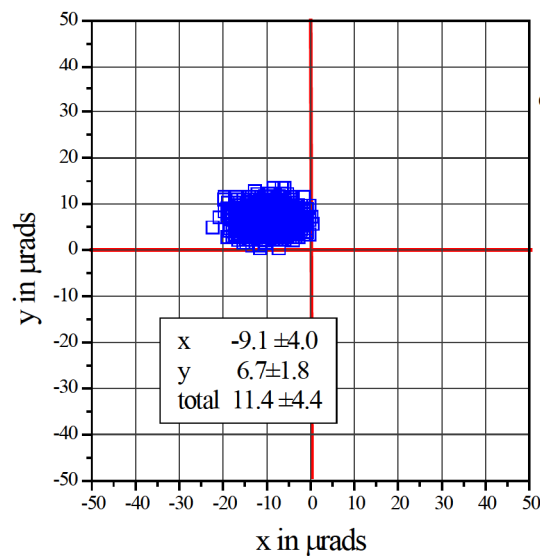
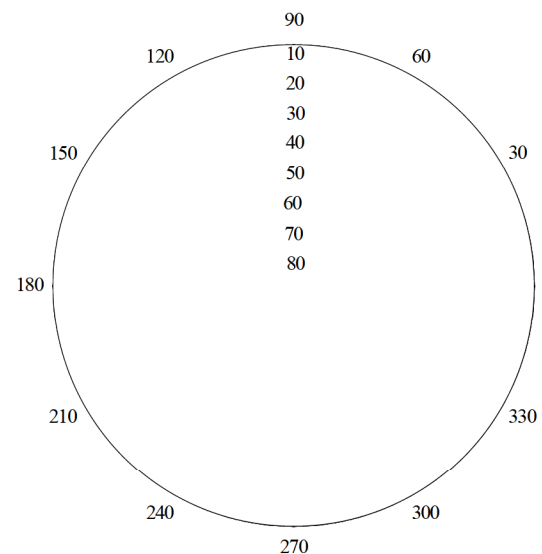
4-LLOT



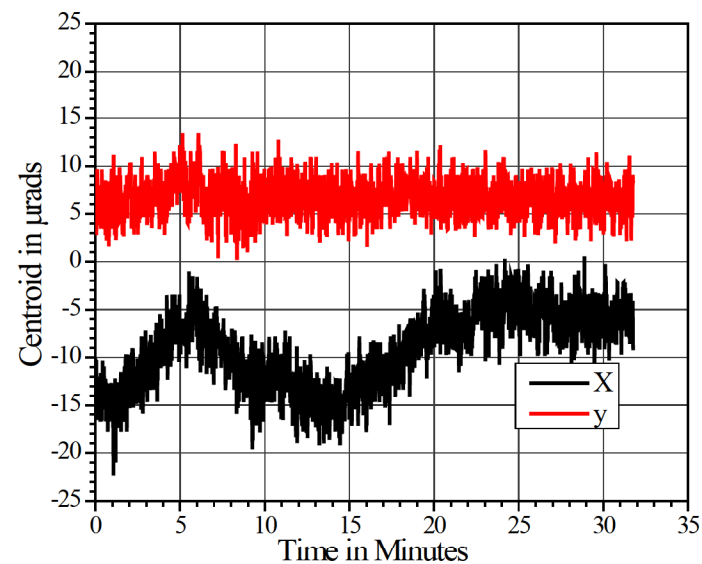
# Blind Pointing



- **All sky blind pointing**
  - Pick stars across sky
  - Measure location



- **Sidereal tracking**
  - Measure star position with time

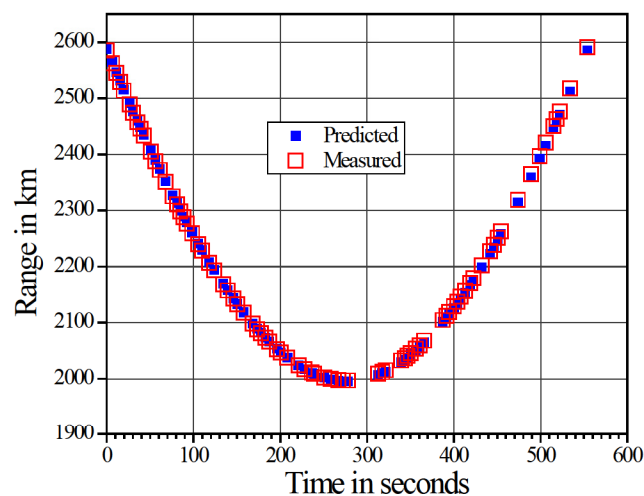
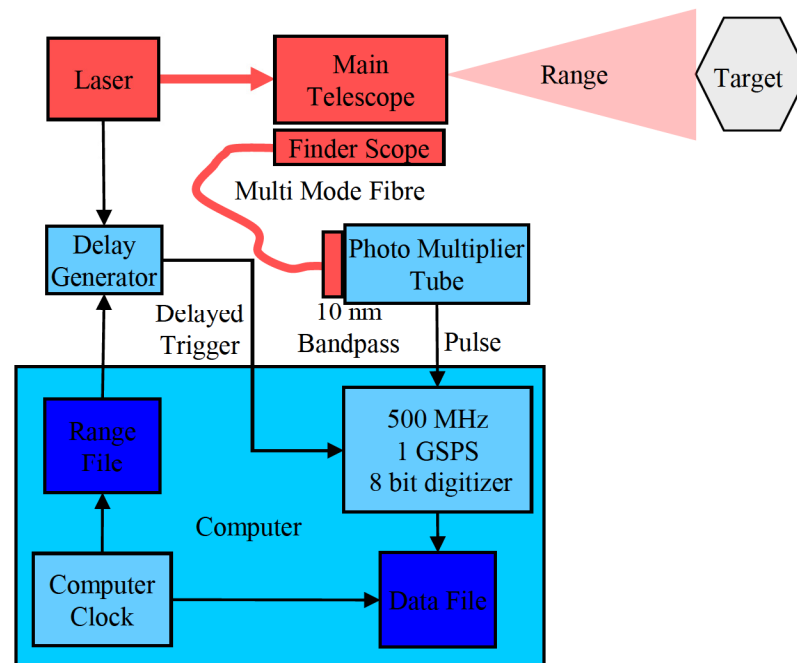
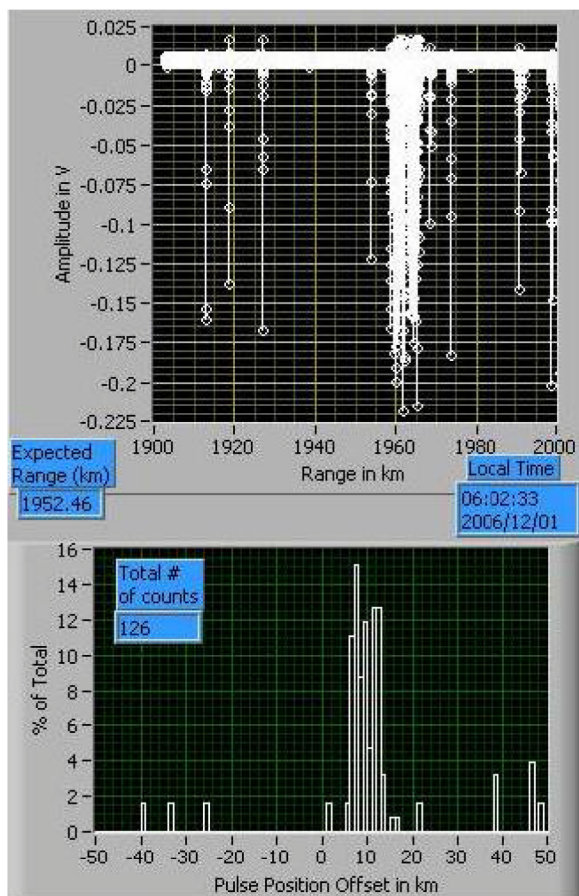




# Satellite Retro Reflector Experiments



- Test telescope blind pointing by targeting geodetic satellites
  - Narrow beams 30-60  $\mu$ rads
  - Both monostatic and bistatic configurations

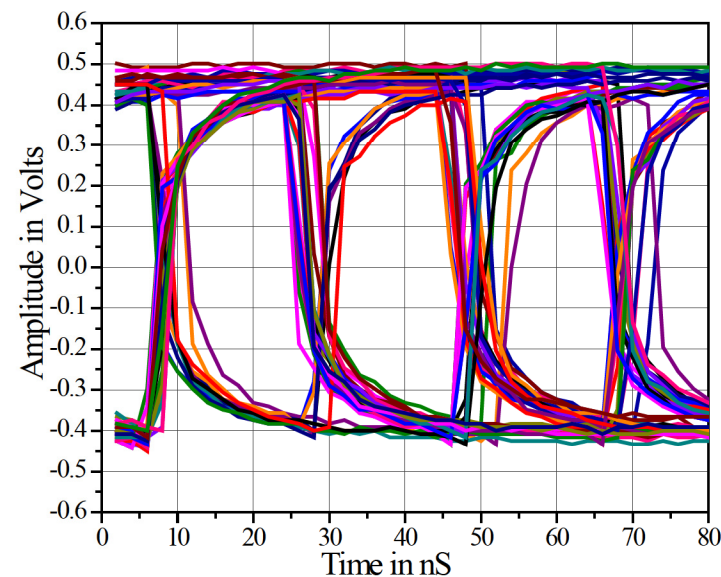
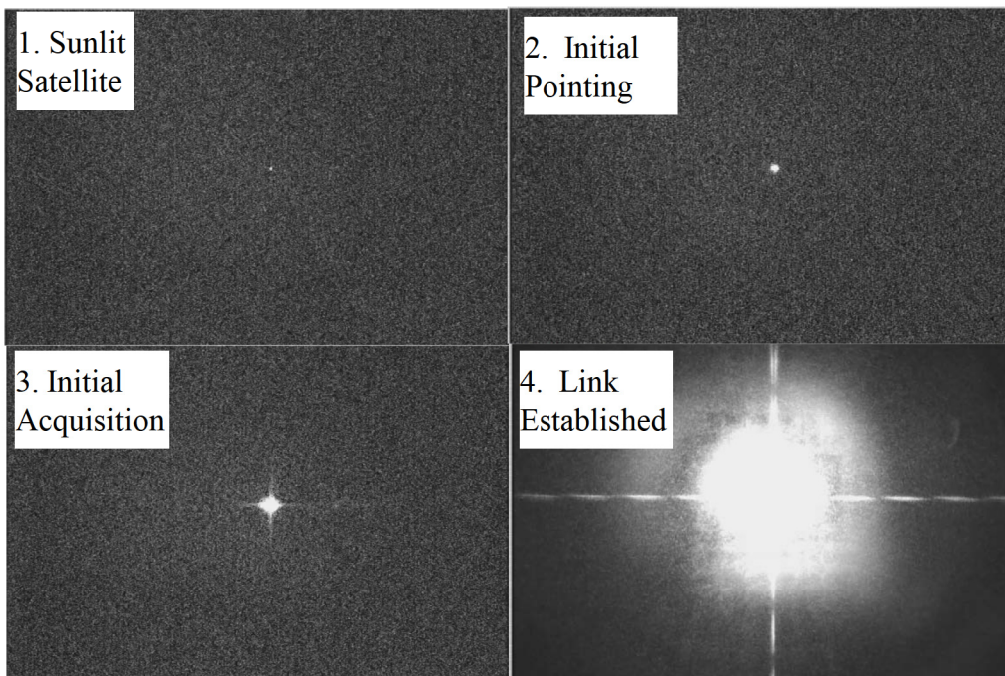
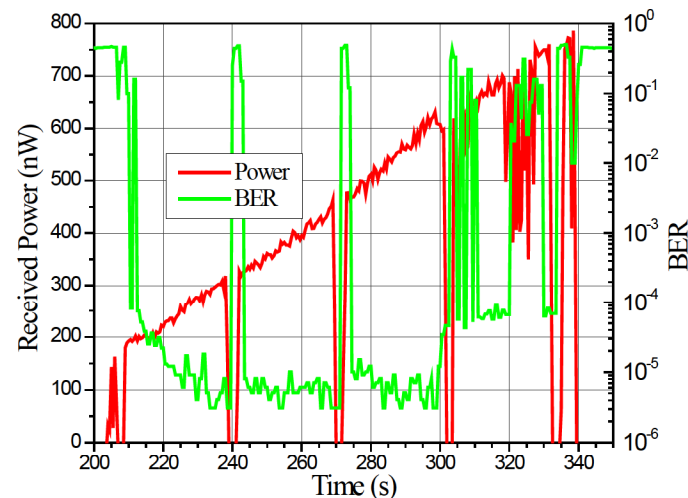




# OICETS Optical Communications Experiment



- **Ground Station for LUCE terminal of OICETS satellite**
  - 50 Mbps OOK PN15 downlink
  - 2 Mbps PN15 PRBS in binary PPM format uplink
- **Blind pointing to ephemeris file**
  - No feedback or fine pointing
- **4 separate links took place on May 21, June 2, June 4 and **June 11**, 2009**
  - Each one successful
- **BER measured in real time**
  - Data snapshots using PCI based digitizer at 500 MHz with 4000 samples taken every 0.5 s

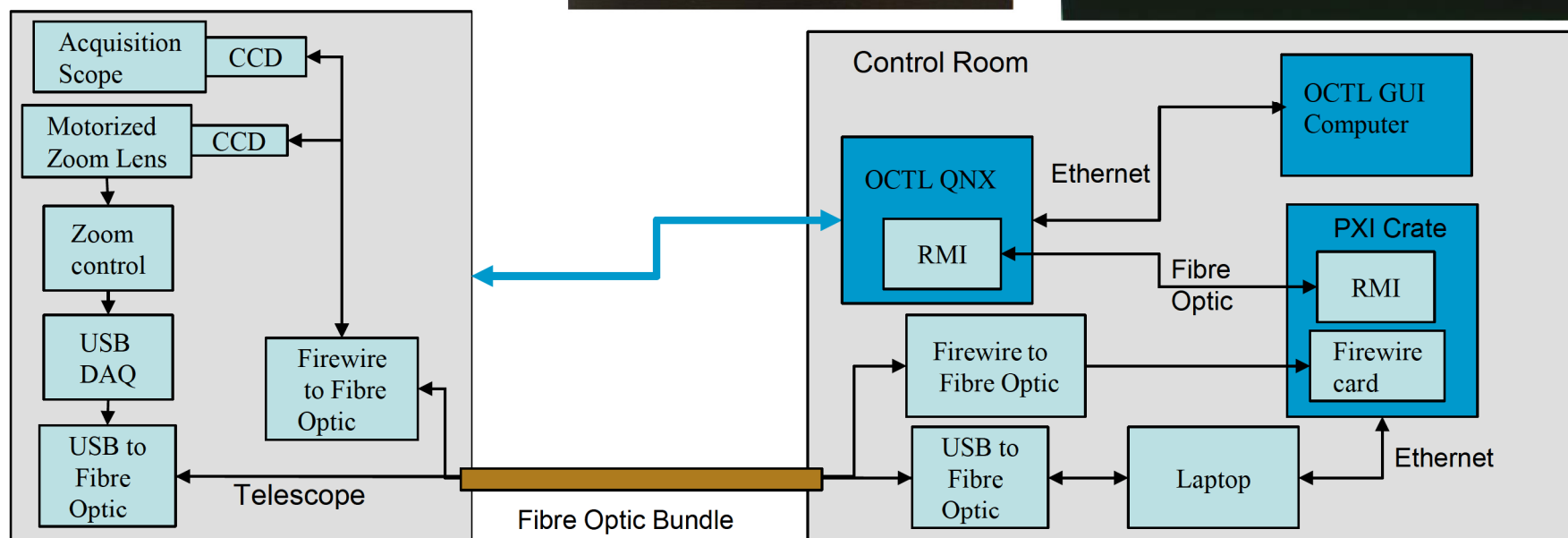
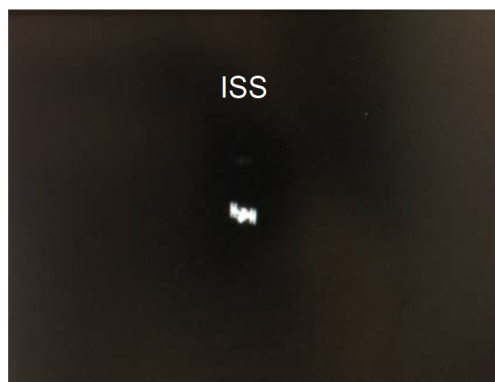




# Real Time Control Upgrade



- **Installed Reflective Memory Interface (RMI) in telescope control computer**
  - Allows reading and writing of all control registers in real time
  - Installed additional camera with motorized zoom lens to allow capture of target and handoff to acquisition telescope
- **Have demonstrated airplane, satellite and star tracking through acquisition scope**





# LLCD Configuration



- Monostatic uplink/downlink through common aperture
- Real time control of telescope and fine steering mechanism using focal plane array
- Ground station telemetry sent in real time over internet
- Optical data and full ground station telemetry sent after pass

